DEVELOPMENT OF VISION AUTONOMOUS GUIDED VEHICLE BEHAVIOUR USING NEURAL NETWORK

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ABSTRACT

This project is motivated by an interest in promoting the use of artificial neural network in manufacturing. Automated guided vehicle (AGV) is used in advanced manufacturing system that can help to reduce cost and increase efficiency. The application of neural network in the AGV is to help in increasing the AGVs performance and efficiency. The objectives of this project are to develop a line recognition algorithm for automated guided vehicle and to understand two types of neural networks that can be use in manufacturing. The types of guidelines used in this project are straight guideline, turn right guideline, turn left guideline and stop guideline. The line recognition algorithm involved the pre-processing images of the guideline captured by a camera and extracts the feature of the images by using first order statistics to calculate the values of mean, variance, skewness and kurtosis and train the image recognition by using neural networks. Neural network process involved setup the two types of neural network, trained and tested the network and compared the result. There are two types of neural network that used in this project namely, Feedforward Backpropagation and Radial Basis. In Feedforward Backpropagation Network the parameter involves are transfer function and number of neurons. Mean Squared Error (MSE) is used as performance function. Radial Basis Network with spread constant one give significantly better performance compared to Feedforward Backpropagation Network. It produced much lower error compared to Feedforward Backpropagation Network. This project used MATLAB software which able to perform image processing tasks, train and simulate neural networks.

ABSTRAK

Projek ini adalah didorong oleh kepentingan dalam mempromosikan penggunaan rangkaian neural buatan dalam pembuatan. Kenderaan berpandu automatik (AGV) digunakan dalam sistem pembuatan termaju yang boleh membantu mengurangkan kos dan meningkatkan kecekapan sistem. Penggunaan rangkaian neural dalam AGV adalah untuk membantu dalam meningkatkan prestasi dan kecekapan AGV. Objektif projek ini adlah untuk membangunkan satu algoritma pengecaman garisan untuk kenderaan berpandu automatik dan memahami dua jenis rangkaian neural yang boleh digunakan dalam sektor pembuatan. Jenis-jenis garis panduan yang digukan dalam projek ini adalah garis panduan lurus, garis panduan kanan, garis panduan kiri dan garis panduan berhenti. Algoritma pengecaman garis yang terlibat ialah pemprosesan imej garis panduan yang ditangkap oleh kamera, pengekstrakan ciri imej dengan menggunakan statistik tertib pertama untuk mengira min, perbezaan, kecondongan dan kurtosis dan melatih pengecaman imej dengan menggunakan rangkaian neural. Terdapat dua jenis rangkaian neural yang digunakan dalam projek ini iaitu Feedforward Backpropagation dan Radial Basis. Parameter yang terlibat dalam rangkaian Feedforward Backpropagation ialah bilangan neuron dan fungsi pindah. Mean Squared Error (MSE) digunakan sebagai fungsi prestasi. Fungsi latihan yang digunakan adalah trainlm. Rangkaian Radial Basis dengan pemalar penyebar satu memberikan prestasi yang jauh lebih baik berbanding dengan rangkaian Feedforward Backpropagation. Ia menghasilkan ralat yang lebih rendah berbanding dengan rangkaian Feddforward Backpropagation. Projek ini menggunakan perisian MATLAB yang mampu melaksanakan tugas-tugas pemprosesan imej, melatih dan mensimulasikan rangkaian neural.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

μ_n	Moments of the gray level histogram
μ	Mean
P_k	Normalized histogram
σ^2	Variance
γ^3	Skewness
γ^4	Kurtosis
δ_j	Error between output and input in backpropagation network
δ_k	Error between hidden layer and output layer in backpropagation network
y_{net}	Output of the Radial Basis Neural Network

LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
ANN	Artificial Neural Network
FMS	Flexible Manufacturing Systems
JPEG	Joint Photographic Experts Group
MSE	Mean Squared Error
NN	Neural Network
RGB	Red Green Blue

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION OF STUDY

Automated Guided Vehicle (AGV) is a kind of intelligent mobile robot, which can move along the guideline. It can operate independently, which means it is able to perform their operations without human direction. In the development of AGV, there are two classification of AGV that are guiding with lines and without lines (Sulaiman Sabikan et al., 2010). AGV also can follow markers or wires in the floor or use laser or vision. The number of AGV use is increasing from year to year. The application of AGV has been expended and no longer restricted to industrial environments. AGVs are widely use in industrial field such as automotive, manufacturing and chemical. With the implementation of the AGV system, it will help to reduce costs and increase efficiency especially in advanced manufacturing system. Usually the implementation of AGV is in the Flexible Manufacturing Systems (FMS) in order to integrating machinery or manufacturing cells, which need material transfer. Generally, the AVG systems consist of a computer software and technology that are the brain behind AGV (Sulaiman Sabikan et al., 2010).

1.2 PROJECT BACKGROUND

An artificial neural network (ANN), usually called neural network (NN) is a data processing system consisting of a large number of simple and highly interconnected processing elements (artificial neurons) inspired by the structure of the cerebral cortex of the brain (Lefteri, H.T. and Robert, E.U., 1997). ANN is a type of artificial intelligence that attempts to imitate the way of human brain works (Sivanandam, S.N. et al., 2011). Basically, neural network deal with cognitive tasks such as learning, adaptation, generalization and optimization. Certainly, recognition, learning, decision making and action represent the principal navigation problems (Janglova, D., 2004). Neural networks perform two major functions that are learning and recall. Learning is the process of adapting the connection weights in an artificial neural network to produce the desired output vector in response to a stimulus vector presented to the input buffer. Recall is the process of accepting an input stimulus and producing an output response in accordance with the network weight structure (Lefteri, H.T. and Robert, E.U., 1997). Learning rules enable the network to gain knowledge from available data and apply that knowledge to assist a manager in making key decisions. Neural networks also able to compute any computational function. It also can be defined as parameterized computational nonlinear algorithms for data, signal and image processing (Sivanandam, S.N. et al., 2011).

Table 1.1 shows the comparison between artificial and biological neural network. Biological neural network or nerve cell consists of cell body, dendrite, soma and axon while artificial neural network consists of neurons, weights or interconnection, net input and output (Sivanandam, S.N. et al., 2011).

Table 1.1: Comparison between artificial neural network and biological neural network

Characteristics	Artificial Neural Network	Biological Neural Network
Speed	Faster in processing information.	Slow in processing information.
Processing	Sequential mode operations.	Massively parallel operations.
Size and complexity	Not involve as much computational neurons. Hence it is difficult to perform complex pattern recognition.	Have large number of computing elements, and the computing is not restricted to within neurons. The size and complexity of connections give the brain power of performing complex pattern recognition tasks.
Storage	In a computer, the information is stored in the memory, which is addressed by its location. Any new information in the same location destroys the old information. Hence here it is strictly replaceable.	Store information in the strengths of the interconnections. Information in the brain is adaptable, because new information is added by adjusting the interconnection strengths, without destroying the old information.
Fault tolerance	Artificial nets are inherently not fault tolerant, since the information corrupted in the memory cannot be retrieved.	Exhibit fault tolerance since the information is distributed in the connections throughout the network.
Control mechanism	There is a control unit, which monitors all the activities of computing.	There is no central control for processing information in the brain. No specific control mechanism external to the computing task.

Source: Sivanandam, S.N. et al. (2011)

Table 1.1 shows that artificial neural network are faster in processing information compare to the biological neural network. Processing for artificial neural network is operating in a sequential mode while for biological neural network can perform massively parallel operations. The size and complexity of connection in biological neural network gives the brain the power of performing complex pattern recognition tasks, which cannot be realized on artificial neural network. For storage, artificial neural network stored information in the memory, which is addressed by its location where new information in the same location will destroys the old information, while biological neural network store information in the strengths of the interconnection where new information is added by adjusting the interconnection strengths without destroying the old information. There is a control unit, which monitors all the activities of computing for artificial neural network while there is no central control for processing information in the brain.

Inspired by biological neural networks, artificial neural networks are massively parallel computing systems consisting of an extremely large number of simple processors with many interconnections. Device based on biological neural networks will posses some of these desirable characteristics such as learning ability, adaptivity, fault tolerance, low energy consumption, generalization ability, massive parallelism and distributed representation and computation. Hence it is reasonable to expect a rapid increase in our understanding of artificial neural networks leading to improved network paradigms and a host of application opportunities. Neural network have remarkable ability to derive meaning from complicated or imprecise data, to extract patterns and detect trends that are too complex to be noticed. A trained neural network can be thought of as an expert in the category of information it has been given to analyze. The basic building blocks of the artificial neural network are network architecture, setting the weights and activation function (Sivanandam, S.N. et al., 2011). Advantages of neural networks are good pattern recognition technique, the system developed through learning rather than programming that consume more time for analyst, flexible in changing environment, can build informative models and can operate well with modest computer hardware (Symeonidis, K., 200).

1.3 PROBLEM STATEMENT

In order to increase AGVs efficiency, the line guideline must be detected and recognized by vision sensor accurately (Sulaiman Sabikan et al., 2010). Neural network is employ in its controller algorithm and vision system as ranging sensor. Therefore, there is need to study the performance of AGV recognized the line by using neural network behaviour algorithm. It is to determine the most suitable type of neural network that can allow the most efficient line recognition algorithm.

1.4 PROJECT OBJECTIVES

The objectives of this project are:

(i) To develop a line recognition algorithm for automated guided vehicle (AGV).
(ii) To understand two types of neural networks that can be use in manufacturing.

1.5 PROJECT SCOPES

Line recognition algorithm for vision AGV is important because it can be a main reference throughout navigation. Meanwhile, guideline is needed as important characteristic for the line recognition. This guideline will be placed on the flat floor surface and it is white colour. The types of guidelines used in this project are:

(i) Straight guideline
(ii) Turn right guideline
(iii) Turn left guideline
(iv) Stop guideline

This project used supervised training where it is a process of providing the network with a series of sample inputs and comparing the output with the expected responses. The training continues until the network is able to provide the expected response (Sivanandam, S.N. et al., 2011). Development of vision AGV behaviour using neural network for this research involves in comparing two types of neural networks which are:

(i) Feedforward backpropagation
(ii) Radial basis

The purpose of comparing these two types of neural network is to find the best type for line recognition besides learn the recognition analysis using neural networks. This is important to improve the AGVs capabilities and increase it efficiency. This project use camera based vision for the vision sensor. Camera based vision system is useful in order to recognize the line guideline and allow line recognition algorithm.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research related to this project. Some of the contents of the research that related to this project are Vision-Based Automated Guided Vehicle (V-AGV), statistical feature extraction and neural networks. The idea of this project is developed from the related article and journal.

2.2 VISION-BASED AUTOMATED GUIDED VEHICLE

A navigation control system for a Vision-Based Automated Guided Vehicle (V-AGV) by detecting and recognizing line tracking can be done by using Universal Serial Bus (USB) camera (Sabikan, S. et al., 2010). The main components used are laptop and low cost USB camera. The vision-based navigation system structure is composed of guideline detection, sign detection and obstacle detection. Through USB camera three algorithms that are guideline detection, sign detection and obstacle detection gain some predictive of knowledge from environment. Line detection algorithm consists of seven types of guidelines that are straight, crossing, turn left, turn right, straight and left, straight and right, and lastly is junction guideline. Besides that, this line detection algorithm is divided into four steps, they are system initialization, image pre-processing, measuring the width of the guideline and recognition and classification of guideline. Sign symbols have been placed on the floor for sign detection algorithm that is used as a direction in the V-AVG navigation (Sabikan, S. et al., 2010).

The experimental results from above research have shown that V-AVG navigation control system have been successfully implemented on the real guideline system. A low cost of USB camera can be use for vision based line recognition and detection algorithm. The USB camera has performed well in executing the proposed algorithm. This control system do not need the destination target to be programmed, it depends on the guideline.

2.3 FEATURE EXTRACTION

Feature extraction is the process of defining a set of features or image characteristics which will most efficiently or meaningfully represent the information that is important for analysis and classification. Much of the information in the data set may be of little value for discrimination. Indeed, pattern recognition using the original measurements is frequently inefficient and may even obscure interpretation (Nurhayati, O.D. et al., 2011). Feature extraction is a special form of dimensionality reduction for pattern recognition and image processing. It can be used in image processing which involves the use of algorithms to detect and isolate various desired portions or shapes (features) from an image or video.

Statistical feature extraction can be used to calculate the value of mean, variance, skewness and kurtosis from first order statistics. First order statistics or moments of the gray level histogram are the nth moment of the (normalized) gray level histogram is given by:

$$\mu_n = \sum_{i=1}^{L} (k_i - mean)^n \, p(k_i) \tag{2.1}$$

where

k_i = gray value of the ith pixel

mean = mean gray value of the pixel set

L = the number of distinct gray levels

$p(k_i)$ = normalized histogram (probability density function of the pixel set)

2.3.1 Mean

Mean is the average of the values in the set of data, obtained by summing the values and dividing by the number of values. Mean also can be defined as a measure of the center of the distribution.

2.3.2 Variance

The variance will tell how much the gray level of pixels differs from the mean value to detect if there are any substantial light or dark spots in the image.

2.3.3 Skewness

Skewness is a measure of the asymmetry of distribution. If the skewness is negative, the data are spread out more to the left. If skewness is positive, the data are spread out more to the right. The skewness of the normal distribution (or any perfectly symmetric distribution) is zero. Data that are skewed left mean that the left tail is long relative to the right tail. Similarly, data that are skewed right means that the right tail is long relative to the left tail (Matthews, 2010).

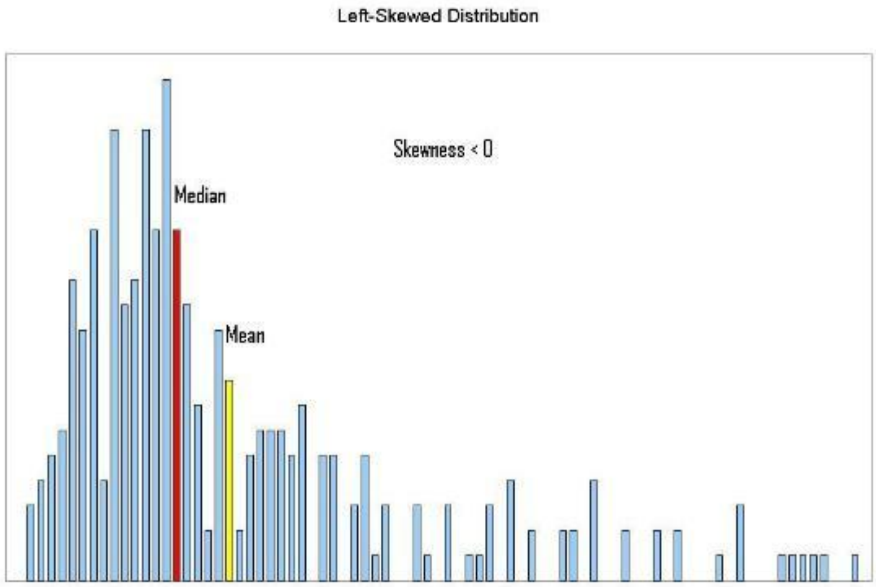

Figure 2.1: Left skewed distribution

Source: Patrick G. Matthews (2010)

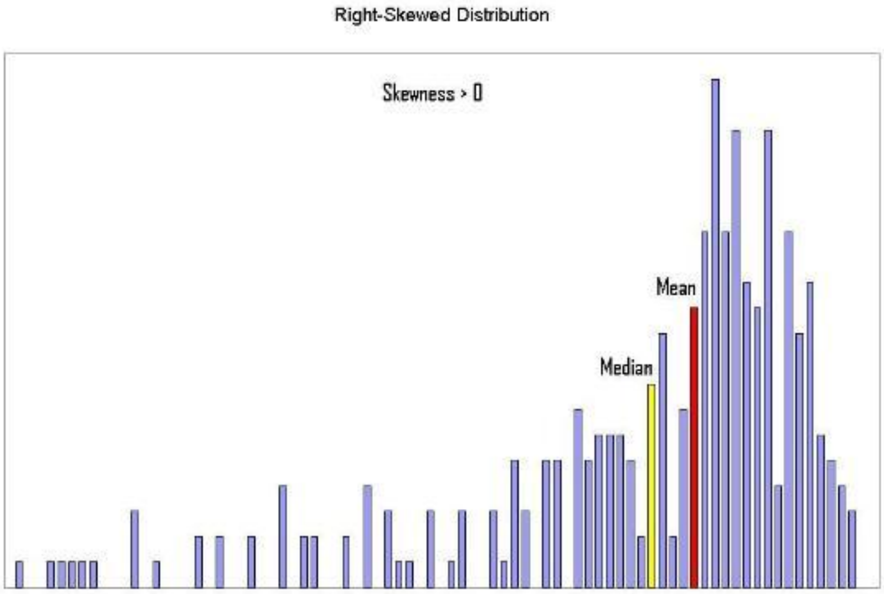

Figure 2.2: Right skewed distribution

Source: Patrick G. Matthews (2010)

2.3.4 Kurtosis

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. That is, data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. Standard normal distribution has a kurtosis of zero. Positive kurtosis indicates a peaked distribution and negative kurtosis indicates a flat distribution (Matthews, 2010).

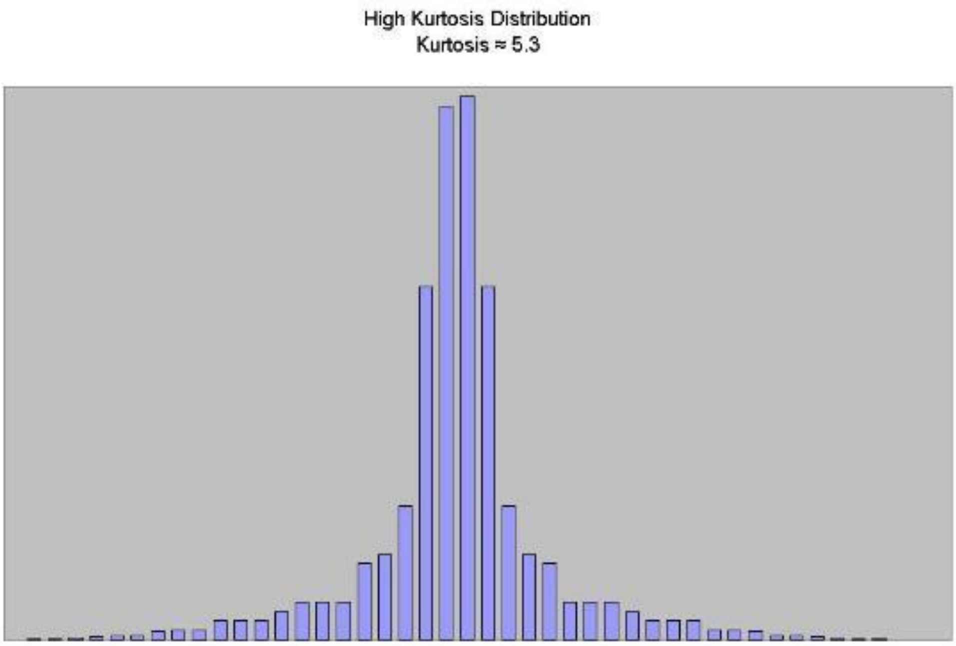

Figure 2.3: High kurtosis distribution

Source: Patrick G. Matthews (2010)

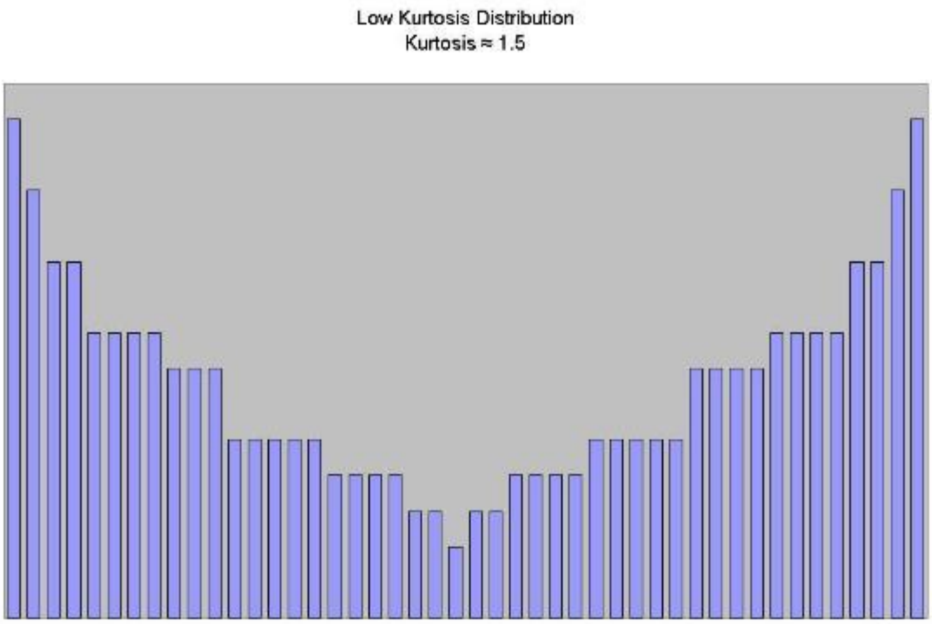

Figure 2.4: Low kurtosis distribution

Source: Patrick G. Matthews (2010)

2.4 NEURAL NETWORK

Neural networks are nonlinear information (signal) processing device, which are built from interconnected elementary processing devices called neurons. It is inspired by the way of biological nervous system, such as brain process information. Neural network is composed of a large number of highly interconnected processing elements (neurons) working in union to solve specific problem. It is configured for a specific application, such as pattern recognition or data classification through a learning process. Through a learning process, knowledge is acquired by the network from its environment. Learning involves the adjustments of the synaptic connections that exist between the neurons. The interneuron connection strengths, known as synaptic weight are used to store the acquired knowledge (Sivanandam, S.N. et al., 2011).

2.4.1 Structure of an Artificial Neural Network

Artificial Neural Networks is an information-processing system. In this information-processing system, the elements called as neurons, process the information. The signals are transmitted by means of connection links. The links posses as associated weight, which is multiplied along with the incoming signal (net input). The output signal is obtained by applying activations to the net input.

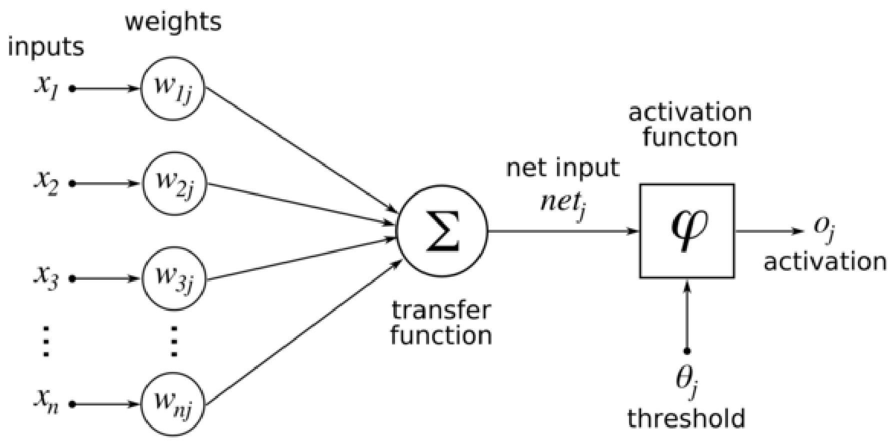

Figure 2.5: Structure of an artificial neural network

Source: Konar Amit (2009)

An artificial neuron is characterized by:

(i) Architecture (connection between neurons)
(ii) Training or learning (determining weights of the connections)
(iii) Activation function

2.4.2 Neural Network Architecture

The arrangement of neurons into layers and the pattern of connection within and in-between layer are generally called as the architecture of the net. The neuron within a layer is found to be fully interconnected or not interconnected. The number of layer in the net can be defined to be the number of layers of weighted interconnected links between the neurons. If two layers of interconnected weights are present, then it is found to have hidden layers (Sivanandam, S.N. et al., 2011). There are various types of network architectures such as Feedforward Net, Competitive Net and Recurrent Net.

Feedforward Networks can be divided into Single layer and Multilayer. Single layer Feedforward Networks has only one layer of weighted interconnections. This type of network consists of only two layers, namely input layer and the output layer. The inputs are directly connected to the outputs. It is strictly a feedforward type and it is called single layer because only the output layer performs the computational. Multilayer Feedforward Networks is consists of multiple layers which it has hidden layers between input and output layer. The hidden layer helps in performing useful computational by extracting progressively more meaningful features from input pattern before directing the input to the output layer. This network also exhibits high degrees of connectivity determined by the synapses of the network. This is advantageous over single layer that it can be used to solve more complicate problems (Sivanandam, S.N. et al., 2011).

Competitive Networks is similar to a Single layer Feedforward Network except that there are connections usually negative between the output nodes. These connections cause the output nodes tend to compete to represent the current input pattern. Sometimes the output layer is completely connected and sometimes the connections are restricted to the units that are close to each other. This type of network has been used to explain the formation of topological maps that occur in many animal sensory systems including vision, audition, touch and smell (Sivanandam, S.N. et al., 2011).

Recurrent Networks is different from Feedforward Networks where it has at least one feedback loop. It is also allow networks to process sequential information. Processing in Recurrent Networks depends on the state of the network at the last time step. Consequently, the response to the current input depends on previous inputs. For Fully Recurrent Networks, all units are connected to all other units and every unit is both an input and an output (Sivanandam, S.N. et al., 2011).

Table 2.1 shows the summary of architectures of neural networks types for Perceptron, Associative Reward-Penalty, Backpropagation, Cohen-Grossberg, Learning